

FIG.1
(Prior Art)

0063515-080900

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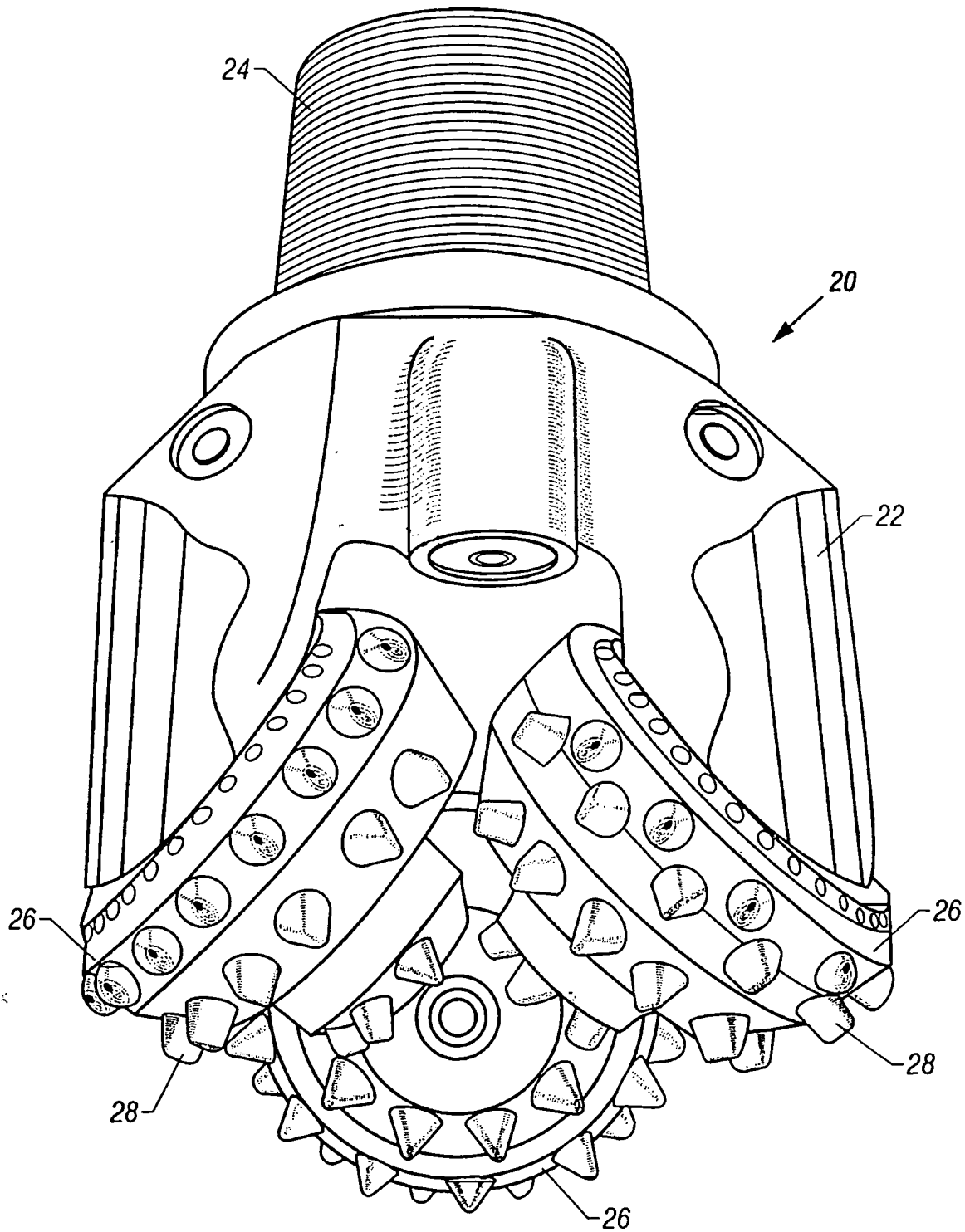
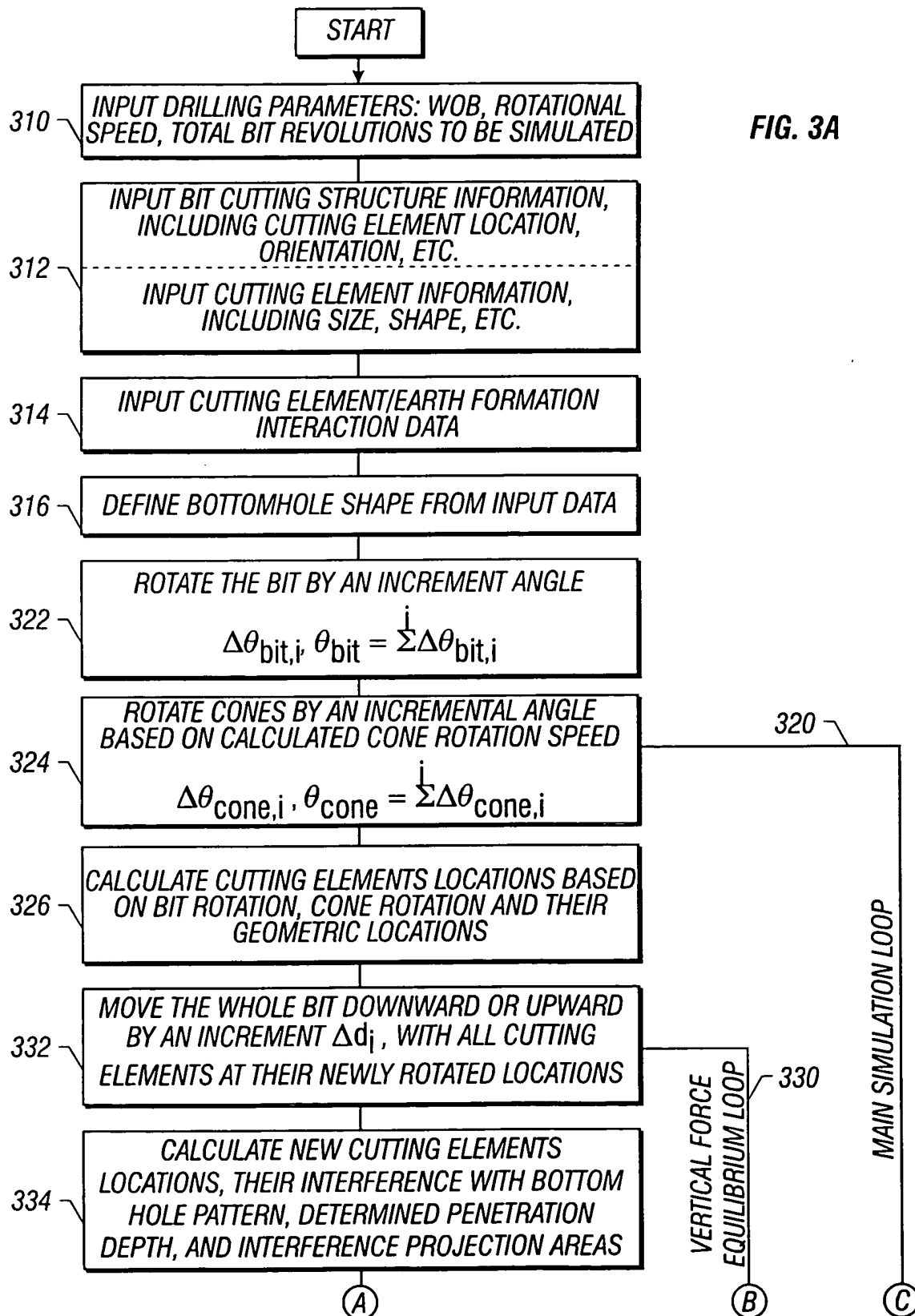


FIG.2
(Prior Art)

09635115-080900

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FIG. 3A



006080" 9TTS966

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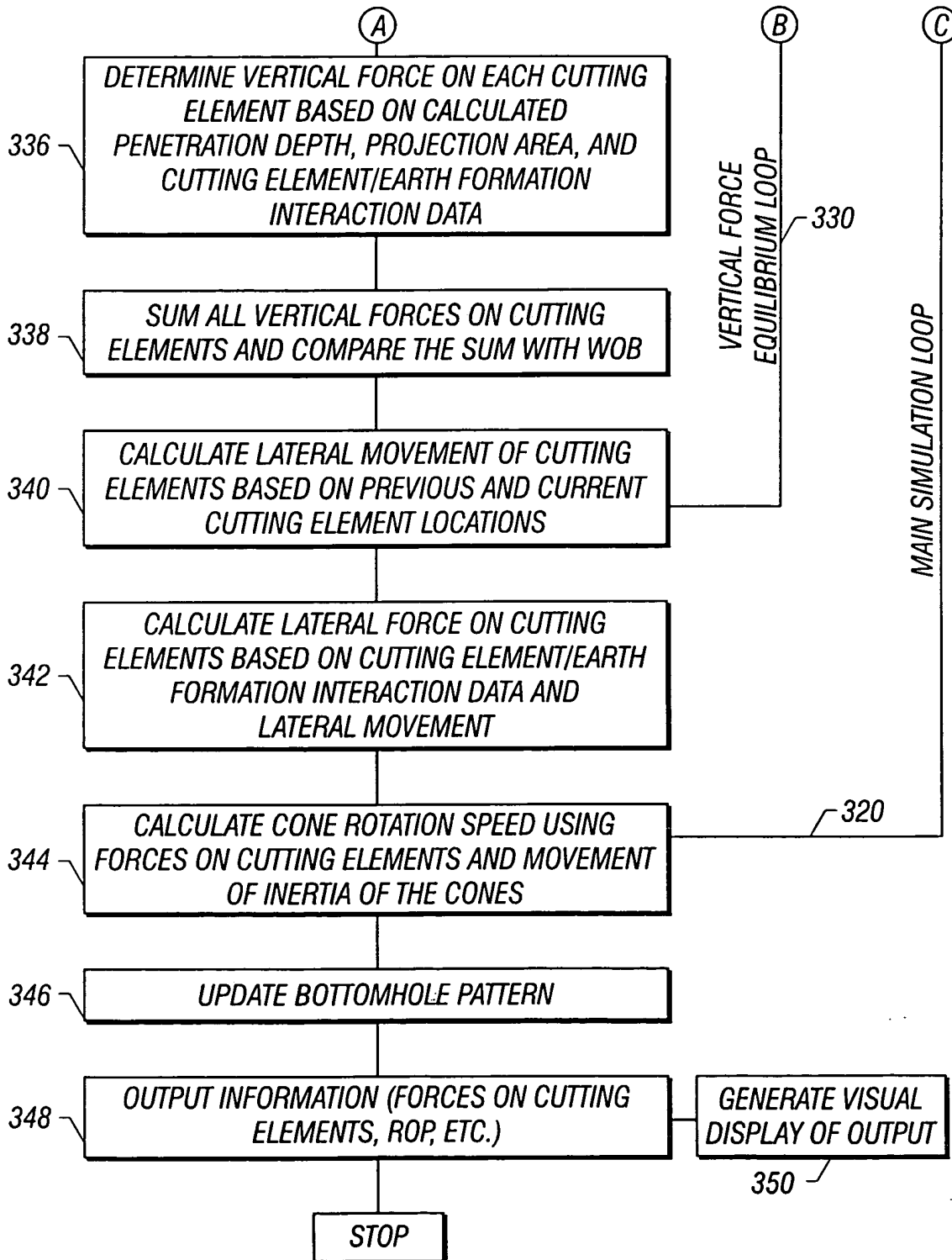


FIG. 3B

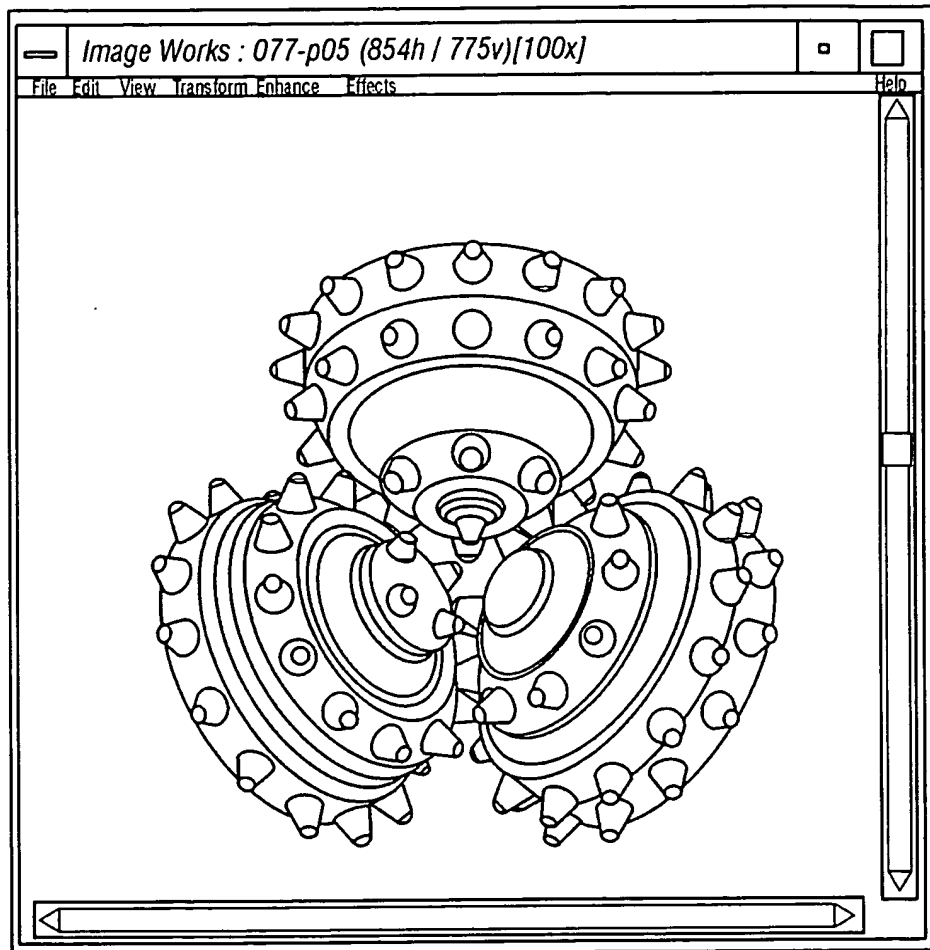


FIG. 4

006080" 9T5E960

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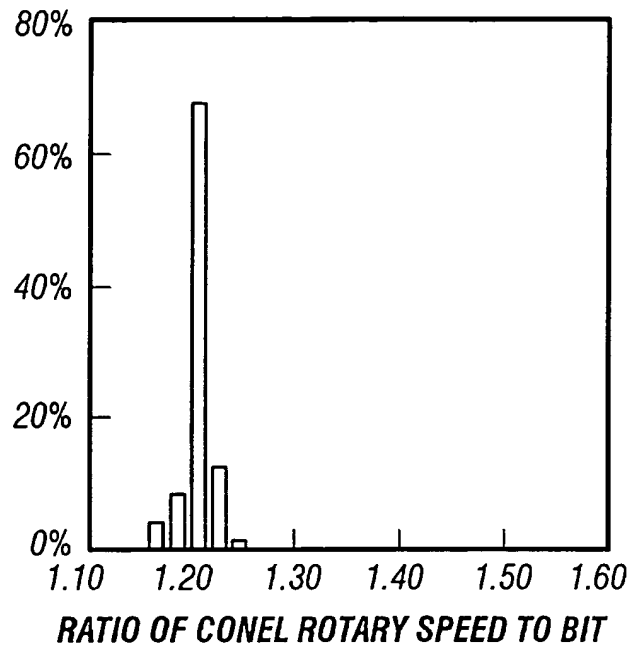


FIG. 6A

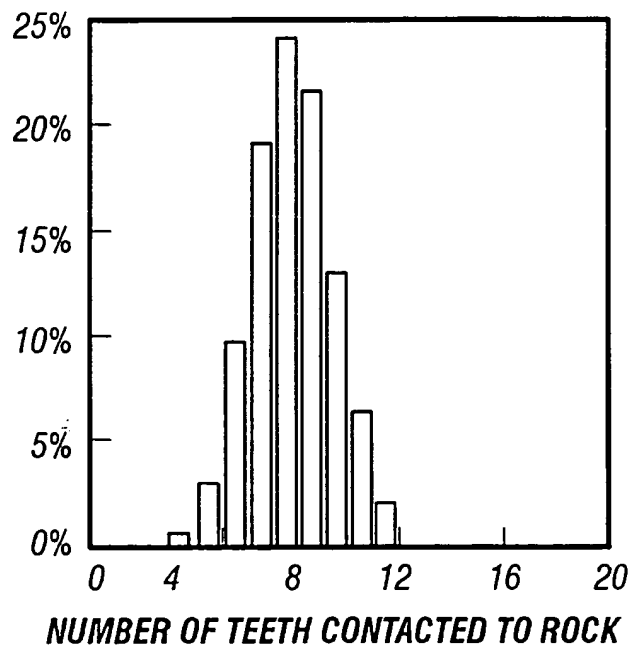


FIG. 6B

09635116-080900

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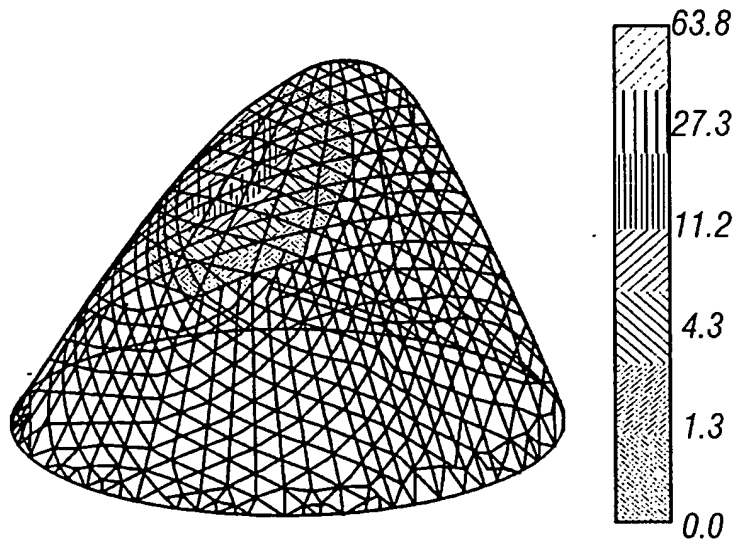
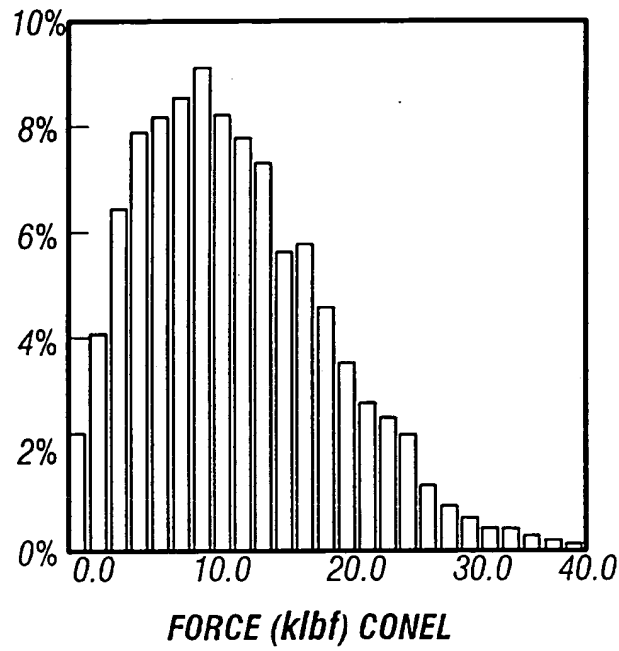
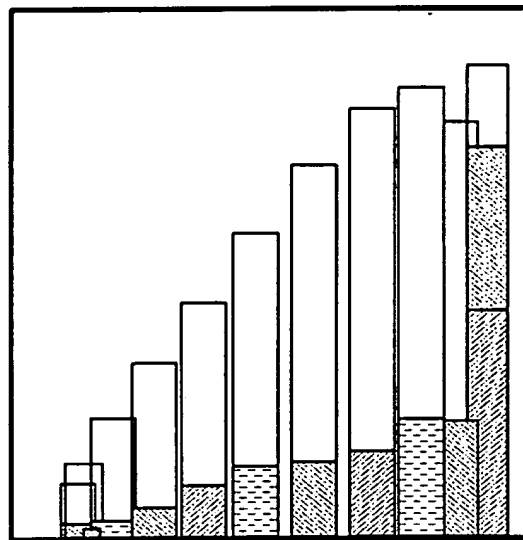


FIG. 6D

09635116-080900

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BOH COVERAGE

FIG. 6E

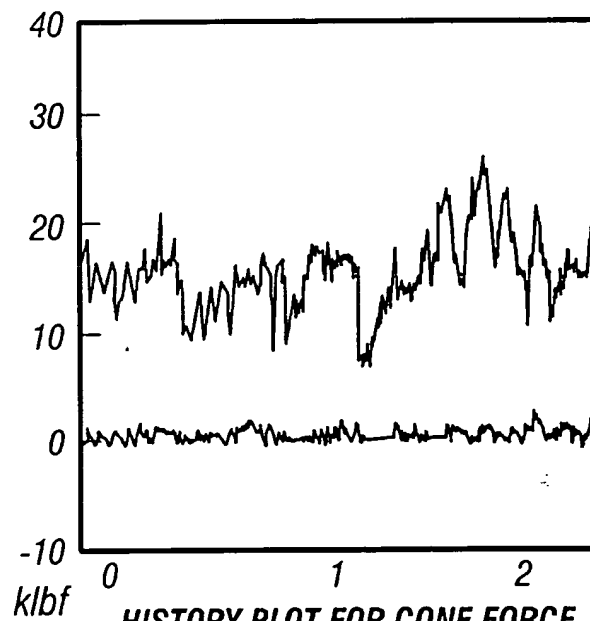
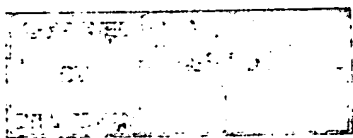


FIG. 6F



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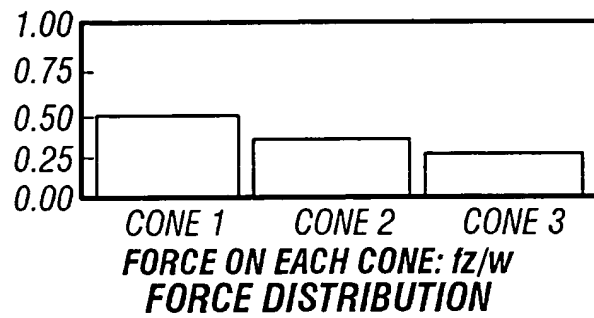
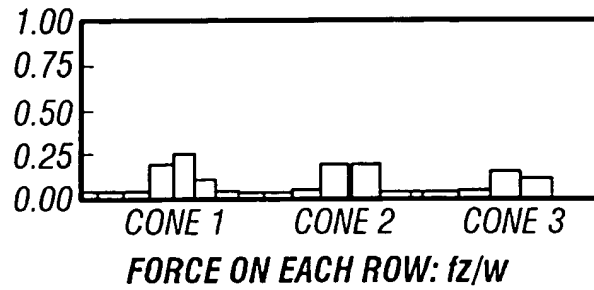
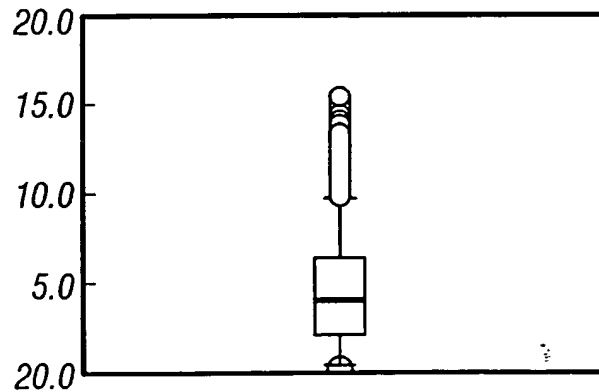


FIG. 6G



FORCE (klbf) 1C-3R
BOX & WISKERS PLOT FOR ROW FORCE

FIG. 6H

006080" 9T5960

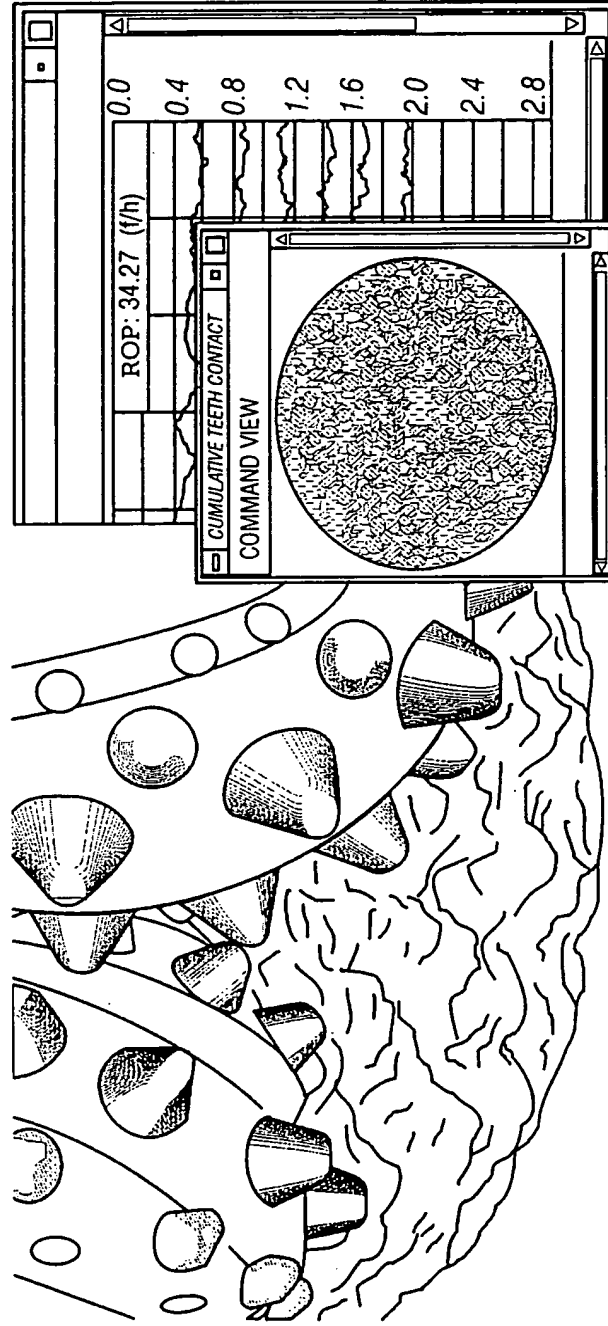


FIG. 7

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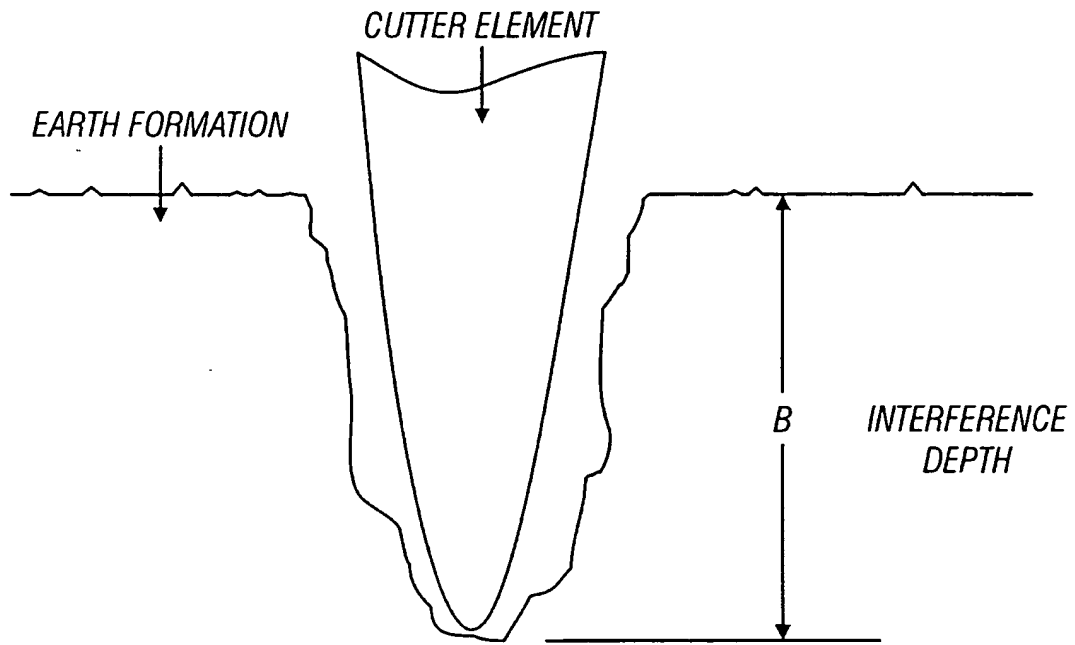


FIG. 8A

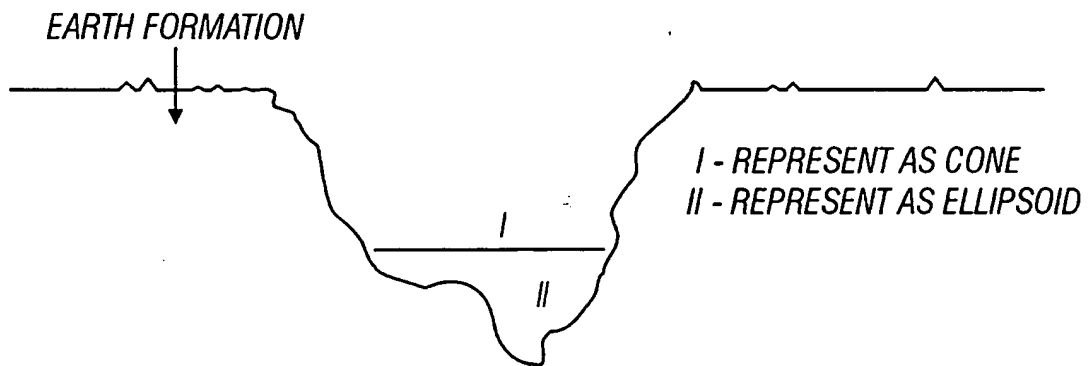


FIG. 8B

006080-9T5E960

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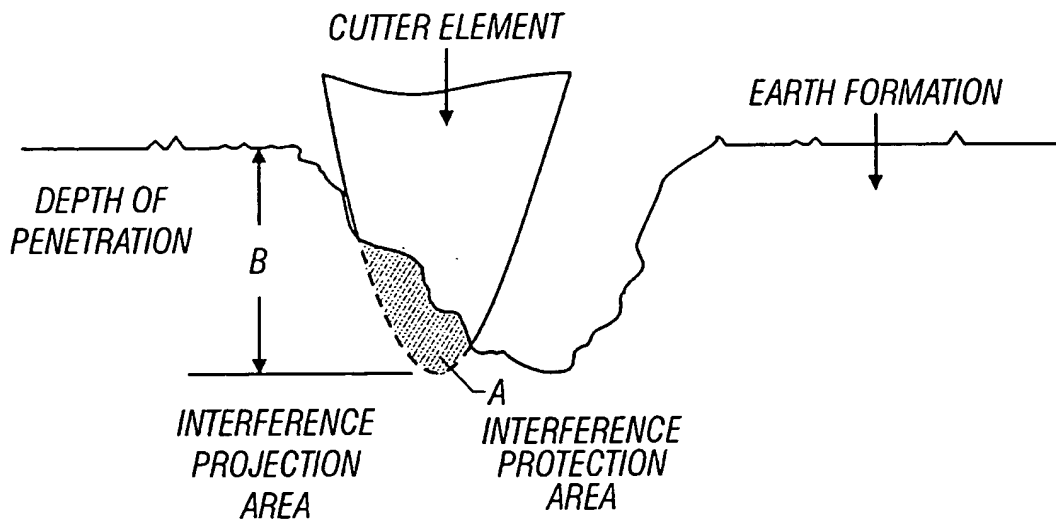


FIG. 8C

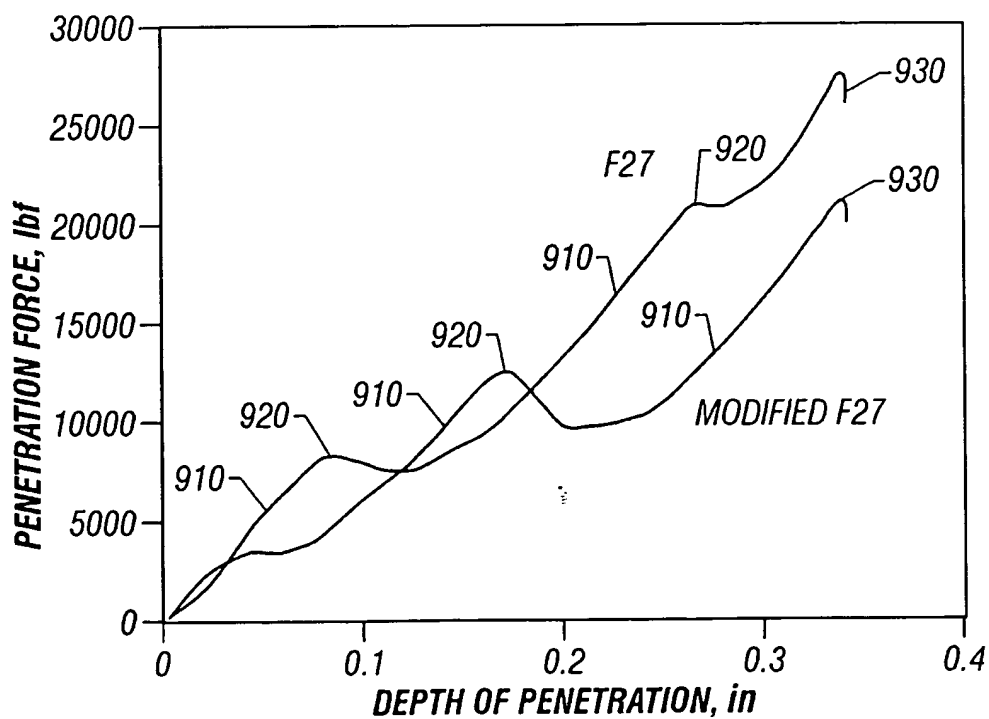
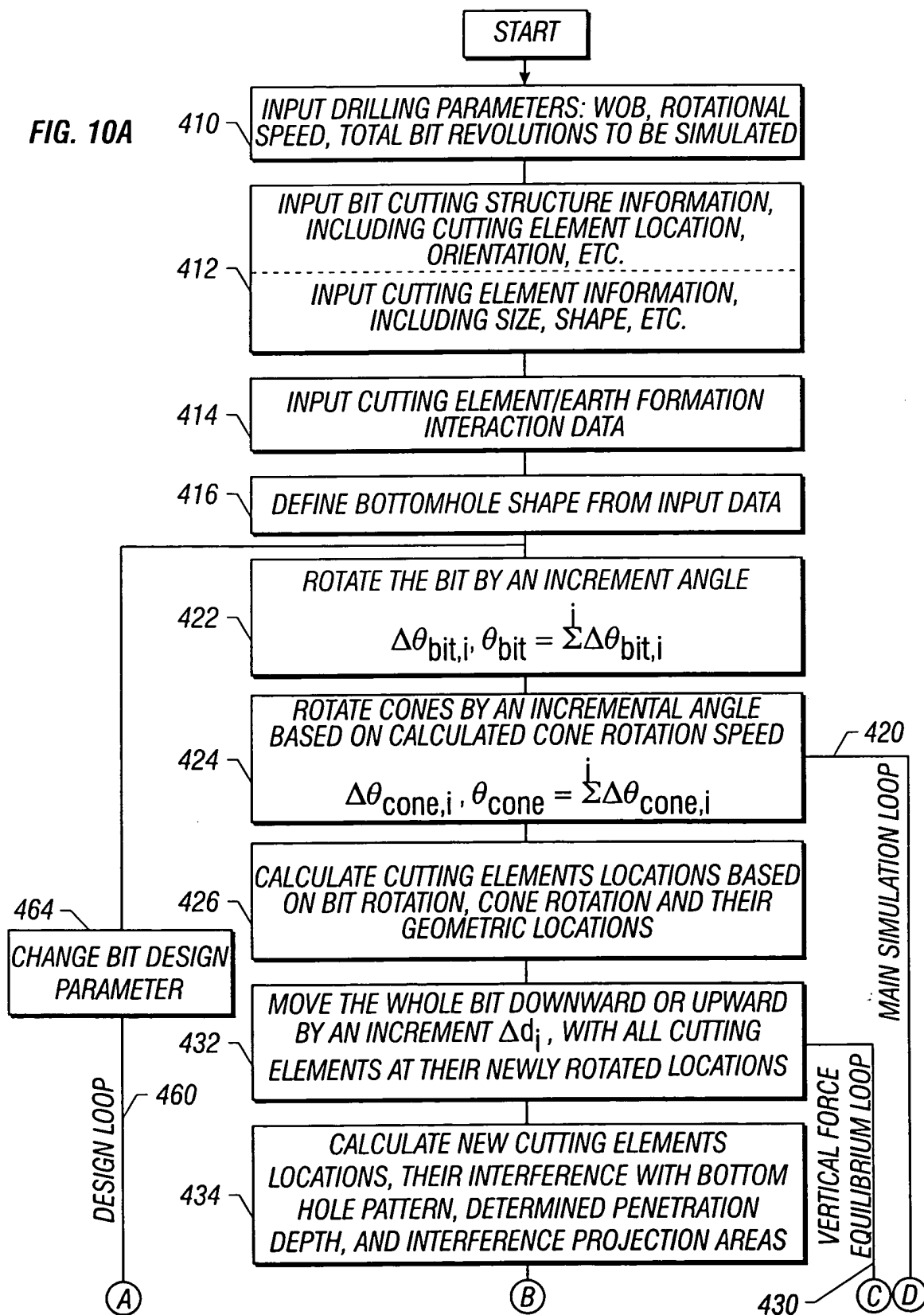


FIG. 9



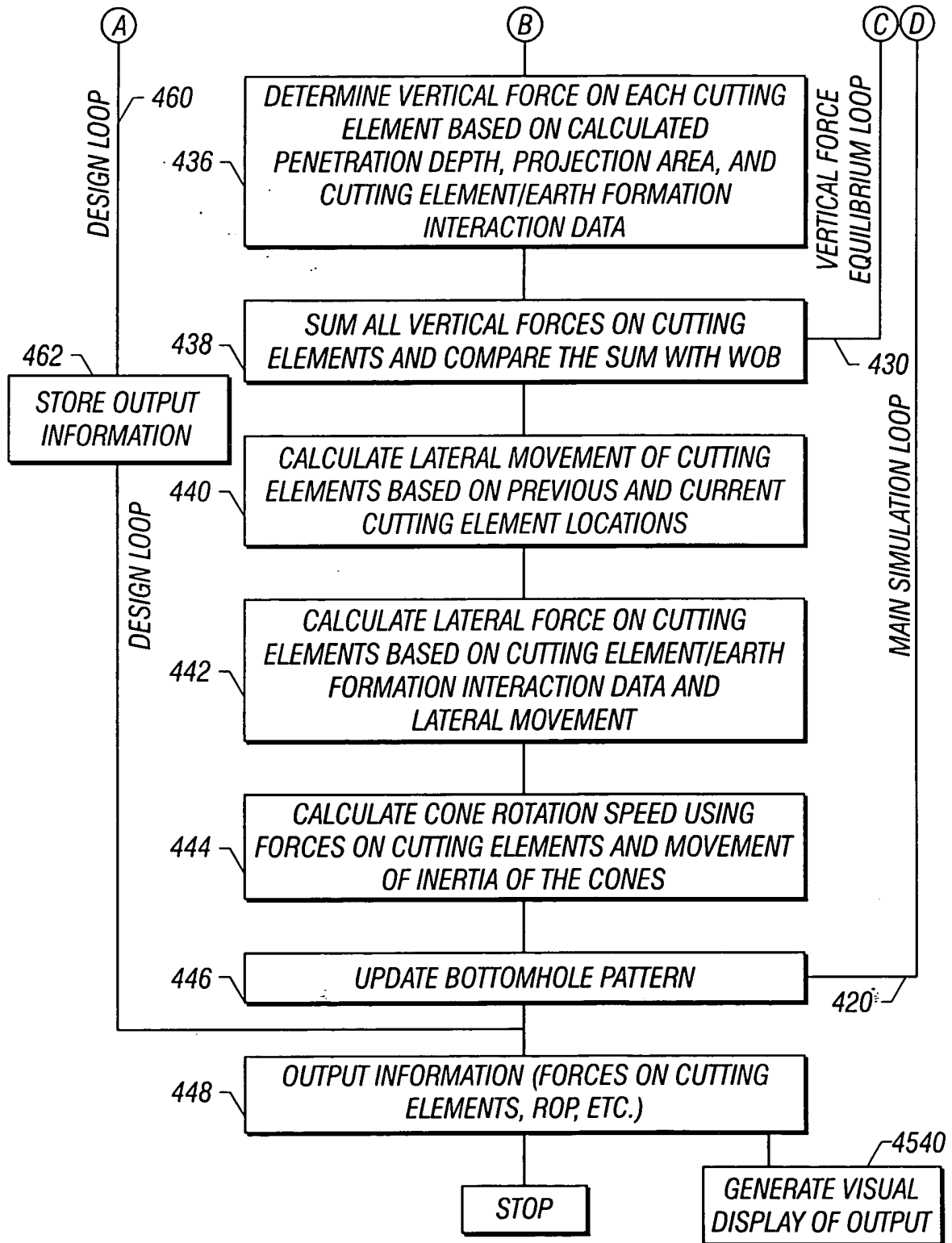


FIG. 10B

FIG. 11A

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graph TD
    START([START]) --> 510[510 INPUT DRILLING PARAMETERS: WOB, ROTATIONAL SPEED, TOTAL BIT REVOLUTIONS TO BE SIMULATED]
    510 --> 512[512 INPUT BIT CUTTING STRUCTURE INFORMATION, INCLUDING CUTTING ELEMENT LOCATION, ORIENTATION, ETC. <br/> INPUT CUTTING ELEMENT INFORMATION, INCLUDING SIZE, SHAPE, ETC.]
    512 --> 514[514 INPUT CUTTING ELEMENT/EARTH FORMATION INTERACTION DATA]
    514 --> 516[516 DEFINE BOTTOMHOLE SHAPE FROM INPUT DATA]
    516 --> 522[522 ROTATE THE BIT BY AN INCREMENTAL ANGLE <br/> Δθ_bit,i, θ_bit = Σ_i Δθ_bit,i]
    522 --> 524[524 ROTATE CONES BY AN INCREMENTAL ANGLE BASED ON CALCULATED CONE ROTATION SPEED <br/> Δθ_cone,i, θ_cone = Σ_i Δθ_cone,i]
    524 --> 526[526 CALCULATE CUTTING ELEMENTS LOCATIONS BASED ON BIT ROTATION, CONE ROTATION AND THEIR GEOMETRIC LOCATIONS]
    526 --> 532[532 MOVE THE WHOLE BIT DOWNWARD OR UPWARD BY AN INCREMENT Δd_i, WITH ALL CUTTING ELEMENTS AT THEIR NEWLY ROTATED LOCATIONS]
    532 --> 534[534 CALCULATE NEW CUTTING ELEMENTS LOCATIONS, THEIR INTERFERENCE WITH BOTTOM HOLE PATTERN, DETERMINED PENETRATION DEPTH, AND INTERFERENCE PROJECTION AREAS]
    532 --> 530[530 VERTICAL FORCE EQUILIBRIUM LOOP]
    534 --> 530
    530 --> 564[564 CHANGE DRILLING PARAMETER]
    564 --> 522
```

510 INPUT DRILLING PARAMETERS: WOB, ROTATIONAL SPEED, TOTAL BIT REVOLUTIONS TO BE SIMULATED

512 INPUT BIT CUTTING STRUCTURE INFORMATION, INCLUDING CUTTING ELEMENT LOCATION, ORIENTATION, ETC.
INPUT CUTTING ELEMENT INFORMATION, INCLUDING SIZE, SHAPE, ETC.

514 INPUT CUTTING ELEMENT/EARTH FORMATION INTERACTION DATA

516 DEFINE BOTTOMHOLE SHAPE FROM INPUT DATA

522 ROTATE THE BIT BY AN INCREMENTAL ANGLE
 $\Delta\theta_{\text{bit},i}, \theta_{\text{bit}} = \sum_i \Delta\theta_{\text{bit},i}$

524 ROTATE CONES BY AN INCREMENTAL ANGLE BASED ON CALCULATED CONE ROTATION SPEED
 $\Delta\theta_{\text{cone},i}, \theta_{\text{cone}} = \sum_i \Delta\theta_{\text{cone},i}$

526 CALCULATE CUTTING ELEMENTS LOCATIONS BASED ON BIT ROTATION, CONE ROTATION AND THEIR GEOMETRIC LOCATIONS

532 MOVE THE WHOLE BIT DOWNWARD OR UPWARD BY AN INCREMENT Δd_i , WITH ALL CUTTING ELEMENTS AT THEIR NEWLY ROTATED LOCATIONS

534 CALCULATE NEW CUTTING ELEMENTS LOCATIONS, THEIR INTERFERENCE WITH BOTTOM HOLE PATTERN, DETERMINED PENETRATION DEPTH, AND INTERFERENCE PROJECTION AREAS

564 CHANGE DRILLING PARAMETER

520 MAIN SIMULATION LOOP

530 VERTICAL FORCE EQUILIBRIUM LOOP

560 DRILLING OPTIMIZATION LOOP

(A) (B) (C) (D)

A

B

530

©

④

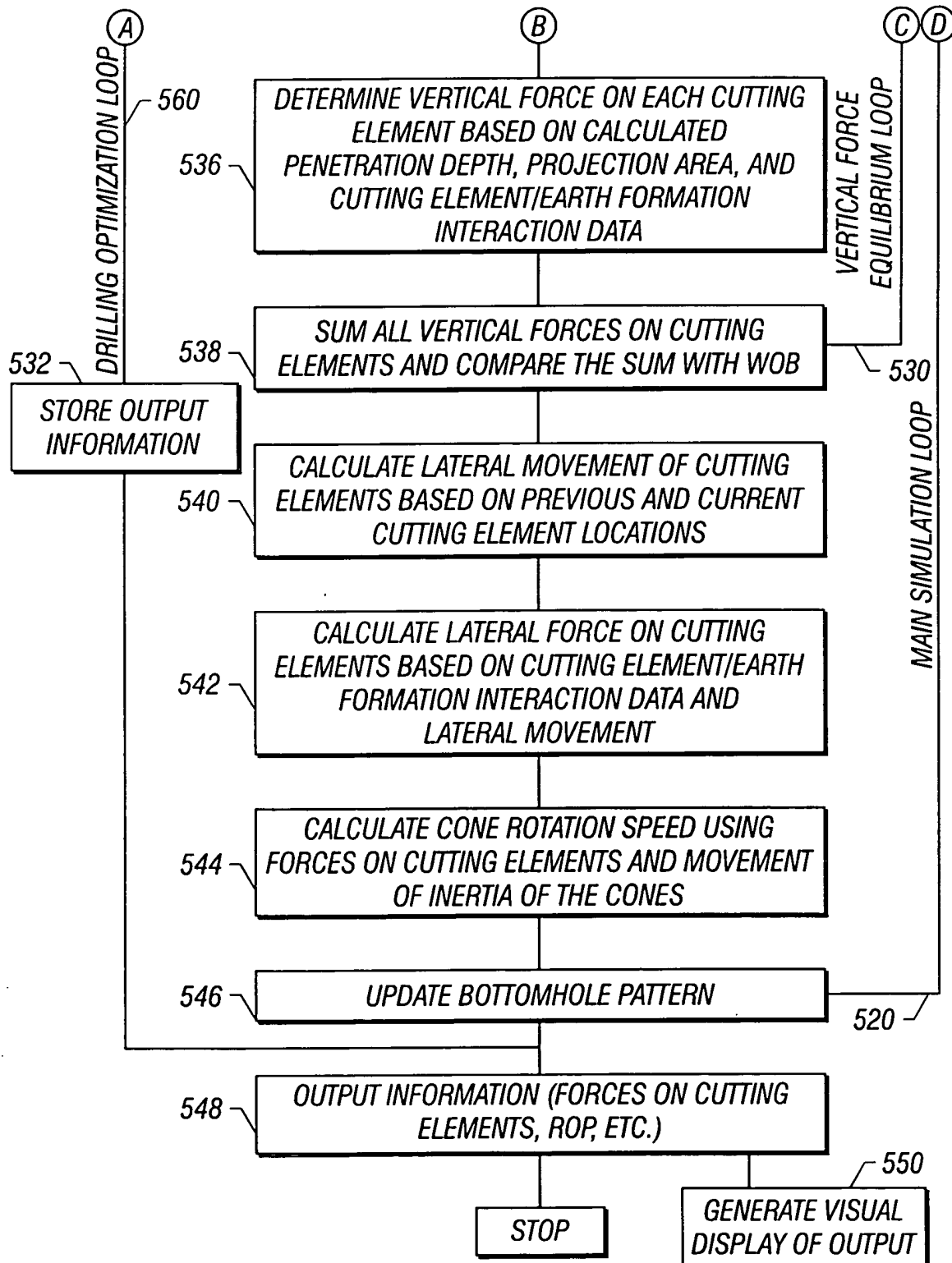


FIG. 11B